Ikigai:Medication Reminder with Facial Recognition

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***Abstract*—This paper introduces ”IKigai,” a cutting-edge robotic system that integrates facial recognition with medication reminder functionalities to enhance adherence to prescribed medication schedules. This system is specifically designed to assist elderly patients and individuals with cognitive impairments, providing a secure, personalized, and reliable healthcare assistant in both clinical and home environments. By leveraging deep learning for facial recognition, IKigai ensures accurate user identification, verifying each patient's identity before dispensing reminders or health notifications. This feature not only improves safety but also minimizes risks associated with medication errors, which are prevalent among patients managing multiple prescriptions.The robot's modular design includes multiple automated functionalities: medication scheduling, real-time user authentication, alarming, and navigation, all of which work together to streamline patient support. By operating autonomously, IKigai also facilitates effective patient-robot interaction, positioning itself as a practical solution in healthcare where direct human oversight is limited. Through continuous monitoring and reminders, IKigai assists patients in adhering to their prescribed regimens, which can reduce hospital readmissions and improve long-term health outcomes. This paper discusses the design, implementation, and testing of IKigai, highlighting its potential as a patient-centered robotic assistant that bridges gaps in healthcare delivery and enhances the quality of life for those needing regular medical management.**

***Keywords*—Medication Adherence,Patient Monitoring,Real-time Tracking,Face Recognition ,Deep Learning,Telemedicine Remote Healthcare Solution**

I. Introduction

”IkiGai,” drawing from the Japanese concept that embodies ”the value of life,” is a healthcare robot meticulously designed to improve patient care through tailored medication reminders and secure facial recognition. This system aims to support elderly patients and individuals managing complex or multiple prescriptions, providing an autonomous, personalized approach to patient assistance within hospitals and healthcare facilities. Inspired by IkiGai's core meaning—finding purpose and value—this robotic solution emphasizes patient safety, privacy, and engagement while addressing several key healthcare needs.IkiGai integrates advanced facial recognition technology for accurate patient identification, ensuring that each interaction is tailored to the patient's unique medical requirements. When programmed with a patient's medication schedule by healthcare providers, IkiGai uses a combination of audio and visual prompts to remind patients of their medication intake. It verifies adherence by tracking confirmation responses, such as a patient's verbal acknowledgment or gesture, and if a dose is missed, it immediately notifies caregivers, allowing timely intervention and increased patient safety. This feature is particularly valuable for individuals with memory impairments or those requiring frequent reminders. The robot's autonomous navigation capabilities allow it to independently move within hospital settings, visiting patients in their rooms, checking in on their condition, or guiding them to specific departments. IkiGai's mobility enables real-time communication between patients and healthcare staff, and its equipped sensors monitor basic health metrics such as heart rate, temperature, and blood oxygen levels. By continuously reporting these metrics to healthcare professionals, IkiGai supports uninterrupted monitoring and early intervention when patients exhibit abnormal signs. This seamless flow of information is critical in delivering responsive, high-quality care without overburdening medical personnel with routine checks.IkiGai not only improves patient engagement by providing a friendly, interactive interface but also reduces the workload on medical staff by automating tasks such as medication reminders and basic health monitoring. Furthermore, the precision of its facial recognition capabilities minimizes errors in patient identification, ensuring that reminders and sensitive information are delivered only to the correct individual, thus preserving patient confidentiality. However, while IkiGai presents significant advancements, the reliance on facial recognition technology raises potential concerns about privacy and data security. Additionally, ensuring IkiGai's reliable navigation and correct patient identification within busy hospital environments poses technical challenges that are central to its ongoing development.In sum, IkiGai exemplifies a significant advancement in integrating robotics and AI within healthcare, creating a patient-centered solution that supports medication adherence, personalized care, and real-time monitoring, thereby aligning with the modern healthcare focus on quality, efficiency, and safety.

II. Literature Review

The paper highlights the challenges faced by families in managing medication schedules for elderly members and patients with conditions like Alzheimer's disease[1].The robot body includes modules for registration, user login, wireless communication, positioning and navigation, weather updates, and medication storage. This comprehensive design allows for effective medication reminders and additional functionalities such as alarming and positioning, which can significantly aid users in managing their medication schedules[2] While modern deep convolutional neural networks (CNNs) have shown remarkable results on large datasets like ImageNet, they often struggle with FER tasks. The literature indicates that shallow CNNs can perform comparably to deeper networks due to issues like overfitting, especially when training data is limited[3].The proposed research focuses on implementing a biometric system that utilizes human facial features for authentication. This system is integrated into a Medical Telediagnosis Robot, which is designed to operate autonomously. The paper outlines a comprehensive design that includes four automated modules: motion detection, face detection, face recognition, and face tracking. Each module employs different algorithms to ensure the system's stability and effectiveness[4]. The integration of robotics in health care has gained traction, particularly with the development of face robots designed to assist patients. These robots can provide reminders for medication and manage health care data, enhancing patient autonomy and care quality[5]. FER is a significant area of research, particularly in enhancing human-robot interaction. Many studies have focused on improving recognition accuracy on specific datasets, but there is a gap in addressing the practical application of these models in real-world scenarios[6]. Traditional methods of medicine handling were often rudimentary, lacking the precision and flexibility of modern AI-driven systems. Older technologies required more manual intervention and were less accurate, which limited their effectiveness in high-demand environments. In contrast, contemporary AI solutions, including those utilizing Digital Signal Processing (DSP) and advanced Programmable Logic Controllers (PLC), offer superior performance[7].Govind, S., Patel., Ashish, A., Desai., Yogesh, Y., Kamble., Ganesh, V., Pujari., Priyanka, A., Chougule., V., A., Jujare. (2023). Identification and Separation of Medicine Through Robot Using YOLO and CNN Algorithms for Healthcare. 1:1-5. doi: 10.1109/icaiihi57871.2023.10489407[8].The paper highlights the significance of face recognition as a leading application of deep learning in real-world scenarios. It emphasizes the need for effective implementation in robots designed for receptionist and security roles, showcasing the growing importance of this technology in various fields[9]., the research compares the current methods of patient identification with the proposed facial recognition approach. It emphasizes the advantages of faster processing times and improved accuracy in patient tracking, which can lead to better healthcare outcomes[10].The paper presents an innovative solution in the realm of automated restroom facilities through the development of a face recognition toilet paper robot. This robot integrates several advanced technologies to enhance user experience and manage resources effectively. Here are the key components and findings from the paper[11].The authors propose an innovative IoT-based medicine reminder and dispensing machine. This machine is designed to store medication doses for an entire week, allowing patients to self-administer their medications while maintaining social distance from healthcare providers. This approach not only protects healthcare workers but also empowers patients, especially the elderly, who may forget to take their medications on time[12]. A significant feature of the system is its ability to monitor the medication-taking process in real time. The sensor unit in the medicine case communicates with the hospital, patient, and acquaintance terminals, allowing for immediate updates and alerts regarding medication adherence. This real-time capability is crucial for timely interventions if a patient misses a dose[13].The paper emphasizes the necessity of face recognition systems in medical settings, particularly for identifying patients in uncontrolled environments. This is crucial for ensuring accurate patient identification, which can significantly impact treatment and care[14].The robot face is engineered with a low-cost approach, employing only seven degrees of freedom (DOF) to create various facial expressions. This design choice is significant as it balances functionality with affordability, making the technology accessible for broader applications in health care settings [15].The implementation of this facial recognition based monitoring system is expected to greatly improve the working efficiency and accuracy of ICU operations. By automating the monitoring process, medical staff can focus on providing care rather than constantly observing patients, thus optimizing workflow in high-pressure environments[18].The method proposed in this paper reflects a growing trend in the use of technology for personal care. It showcases how electronic devices can be leveraged not just for communication or entertainment, but also for enhancing personal grooming and hygiene. This aligns with broader research trends focusing on the intersection of technology and daily life [17]. Attendance marking systems are essential in educational institutions for tracking student presence. Traditional methods, such as roll calls and sign-in sheets, are often time-consuming and prone to errors. The integration of technology, particularly face recognition, has emerged as a promising solution to enhance efficiency and accuracy in attendance management[18].The literature review discusses the development of medical dispenser systems that enhance the distribution of medications, particularly in light of the challenges posed by infectious diseases. It emphasizes the necessity for efficient solutions to minimize crowded environments that heighten contamination risks. The integration of face recognition technology, specifically using Histogram Oriented Gradients (HOG), is highlighted for its ability to securely identify authorized users without physical contact, thus reducing virus transmission. Additionally, the use of machine learning algorithms in the system allows for effective face recognition, achieving an accuracy of 80 based on image inputs, thereby improving automated medical supply dispensing. The system also incorporates a web-based interface, developed using PHP, to enable pharmacists to manage inventory and communicate with patients, facilitating timely notifications about medication supplies. Overall, the implementation of this innovative dispenser system is poised to enhance healthcare delivery by minimizing physical interactions and streamlining the medication retrieval process, making it particularly beneficial in hospital settings[19].The medicine automatic reminder system aims to address the common issue of patients forgetting to take their medications on time, which can hinder treatment effectiveness and patient adherence. It features a box with twelve timing switches and indicator lights, allowing users to set reminders for various medications, along with a power supply switch and a delay button for enhanced control. When activated, a magnetic hour pointer aligns with reed switches to trigger an audible reminder through a horn at the designated times. The system includes an electronic clock for user-friendly operation and portability, integrating simple electronic components to create an effective medication adherence solution. By providing timely reminders, the system seeks to improve health outcomes and highlights the importance of innovative solutions in patient management[20] The literature review of the Medical Tele-Diagnosis Robot (MTR) paper highlights its increasing importance in healthcare, especially in rural areas with limited medical access. It identifies key challenges, particularly in visual communication between specialists and patients, necessitating enhancements for effective tele-diagnosis. To address these challenges, the paper introduces a face identification and tracking system to automate visual interactions, ensuring medical professionals maintain clear contact with patients. Additionally, it discusses a motion detection module, which utilizes an improved technique suitable for real-time applications in dynamic environments, achieving a motion detection accuracy of 96 and contributing to an overall system accuracy of 97. This technical foundation is essential for the MTR's reliability in tele-diagnosis settings[21].The literature survey on face recognition using deep learning in healthcare kiosks highlights the advantages of biometric authentication systems, particularly facial recognition, over traditional methods like RFID cards and passwords, which have limitations such as loss and forgetfulness. The study focuses on the use of Convolutional Neural Networks (CNNs) to enhance face recognition accuracy and efficiency, evaluating four architectures: VGG16, ResNet50, Xception, and MobileNet. While VGG16 achieved a perfect accuracy of 100 in testing, it struggled with real-time detection; ResNet50 also performed well with 99.531 accuracy in real-time scenarios. Xception and MobileNet had lower accuracies of 80.018 and 92.934, respectively, with similar real-time detection issues. The findings underscore the potential for deep learning-based facial recognition to improve security and streamline user experiences in healthcare kiosks, suggesting future research to optimize CNN architectures for real-time applications[22].The paper discusses the development of a medicine-taking reminder IoT system aimed at improving medication adherence among patients. This system comprises a medicine case with compartments for organized storage and a sensor space for monitoring usage, alongside interconnected terminals for hospitals, patients, and acquaintances. These terminals feature applications that track medication information, facilitating real-time monitoring of medication intake and enabling timely alerts for missed doses. Designed with a patient-centric approach, the system not only provides reminders but also fosters communication among caregivers, thereby supporting patients in following their prescribed regimens. The potential impact of implementing this IoT system includes enhanced adherence rates, reduced complications from missed medications, and improved overall health management, highlighting a significant advancement in technology's role in healthcare[23].The literature review explores the use of facial recognition as a biometric system in healthcare kiosks, highlighting its advantages over traditional methods like RFID cards and passwords due to its enhanced security and user-friendliness. The authors propose a deep learning-based login system that utilizes Convolutional Neural Networks (CNNs) to improve the accuracy and reliability of facial recognition. The study tests four CNN architectures—VGG16, ResNet50, Xception, and MobileNet—assessing their performance in real-time face detection, with VGG16 achieving 100accuracy but lacking real-time efficiency, while ResNet50 showed high accuracy (99.531) and effective real-time detection. Xception and MobileNet had lower accuracies of 80.018 and 92.934 , respectively. The findings suggest that implementing these deep learning techniques can significantly enhance user authentication in healthcare kiosks, improving both security and user experience, and contributing to advancements in biometric systems in the healthcare sector.[24] The literature on face recognition technology in healthcare kiosks emphasizes its advantages over traditional biometric systems like fingerprint and iris recognition, which can be limited by issues of loss or forgetfulness. The integration of deep learning, particularly through Convolutional Neural Networks (CNNs) such as VGG16, ResNet50, Xception, and MobileNet, has significantly improved image recognition capabilities. The study compares these architectures, revealing that VGG16 achieves 100 accuracy but struggles with real-time detection, while ResNet50 offers high accuracy (99.531) and performs well in real-time applications. In contrast, Xception and MobileNet have lower accuracies (80.018 and 92.934, respectively) and also face real-time detection challenges. The research underscores the need for effective user identification in real-time scenarios and calls for further exploration to enhance system robustness across varying lighting conditions and diverse user demographics[25].The literature review discusses REMICARE, an Android application designed to improve medication adherence and enhance communication between patients and healthcare providers. Key features of REMICARE include an automated reminder system that alerts patients to take their medications on time, a user-friendly interface for easy navigation, and advanced image processing capabilities for efficient medication management. The app also provides secure cloud storage for medical records, facilitating better interaction between patients and doctors, especially for remote consultations during the COVID-19 pandemic. Security is a priority, with the use of RSA encryption and gravitational search algorithms to protect user data, while medication expiry notifications further ensure patient safety[26].The paper titled ”Design of medical robot control system based on single-chip microcomputer” outlines a novel medical robot designed to enhance healthcare operations, particularly in managing COVID-19 prevention. The main goal is to assist healthcare services by improving efficiency and reducing manpower needs during the pandemic. The robot is built around the STC89C52 single-chip microcomputer, allowing for effective control of its functions. It features infrared sensors for obstacle detection and navigation, along with a tracking module for optimal pathfinding. Movement is controlled by two DC motors using an L298N drive template, ensuring precise maneuvering. An intelligent path planning mechanism employs a genetic algorithm to optimize inspections, while an OV2640 camera, powered by an STM32F4 microcontroller, enables data collection and facial mask recognition using the yolov5s algorithm. This functionality allows for real-time communication of patient information to healthcare providers, enhancing safety and operational efficiency in medical environments[27].The literature review on medication reminder systems emphasizes the critical importance of medication adherence for effective treatment and recovery, as many patients forget to take their medications on time. It discusses existing technology-based solutions, such as the Wedjat smartphone application, aimed at reducing medication administration errors. The proposed system in the review utilizes an Android application that incorporates Optical Character Recognition (OCR) and Artificial Neural Networks (ANN) to improve the accuracy of medication reminders, particularly in interpreting handwritten prescriptions. The choice to develop the application for Android is strategic, given its significant market share, ensuring broader accessibility. The review also points to future enhancements that could make these systems more user-friendly, such as personalized medication information and flexible reminder options, ultimately aiming to promote better medication adherence among users[28].The literature review on face recognition in medical applications highlights the significant evolution of face recognition technology and its growing relevance in healthcare. It explores various medical applications, such as patient identification,monitoring, and improving the accuracy of medical records, which can streamline processes and enhance patient care. The review emphasizes the integration of deep learning technologies, which enhance face recognition capabilities in complex medical scenarios, leading to innovative solutions in medical engineering. One notable application discussed is the use of face recognition in rehabilitation robotics, allowing for improved patient interaction and personalized therapy sessions. The paper concludes by addressing the promising future prospects of face recognition in transforming medical practices, with ongoing research indicating its potential to significantly enhance healthcare delivery and patient outcomes[29].The literature review on face recognition in robotics emphasizes its significance for effective human-robot interaction, particularly in ensuring safety and personalization. It focuses on video-based recognition methods suited for mobile robots, enabling continuous individual tracking for interaction. The authors investigate various still-image recognition techniques, highlighting the superiority of combining Principal Component Analysis (PCA) and Support Vector Machines (SVM), optimized with genetic algorithms, over traditional methods like eigenface and Fisherface. A key contribution is the integration of face recognition within a particle filtering framework, which enhances adaptability in dynamic environments by fusing different measurement sources. Evaluations in crowded indoor settings demonstrate the robustness of the proposed tracking system against real-world challenges. The authors suggest future research directions to improve algorithm efficiency, accuracy, and adaptability in robotic face recognition systems[30].

III. METHODOLOGY

The methodology outlines the design and implementation of a robotic system aimed at enhancing medication adherence through the integration of facial recognition and conversational AI technologies. The **objective** of this project is to develop a robotic system capable of accurately identifying patients and reminding them of their medication schedules, thereby significantly improving adherence rates while providing a personalized and interactive experience. By combining facial recognition for individualized patient identification and a conversational interface for engagement, this system directly addresses the prevalent issue of medication non-adherence among patients who require consistent medication routines. The **system architecture** is thoughtfully designed to integrate three main components: a **Facial Recognition Module**, a **Database**, and a **Conversational AI Module**, all coordinated within a robotic platform to create a seamless and user-friendly patient experience. The **Facial Recognition Module** employs a camera to capture images of patients. These images are processed using advanced facial recognition algorithms that ensure accurate patient identification. This module is critical for confirming the identity of each patient prior to delivering medication reminders, ensuring that each interaction is specifically tailored to the correct individual. The **Database** serves as a structured repository that stores vital patient profiles, medication schedules, and interaction logs. This central database contains comprehensive details for each patient, including identifiers such as names, ages, and photographs, alongside specific medication dosages and schedules. This organized structure enables the system to retrieve each patient’s unique medication schedule and update the log after each interaction. The **Conversational AI Module** enhances the patient experience by engaging them through natural language processing (NLP). This module creates an interactive environment where the robot can prompt patients to confirm their medication intake while also responding to basic queries and concerns. By providing timely reminders and effectively recording patient responses, the conversational module significantly contributes to monitoring adherence over time. In terms

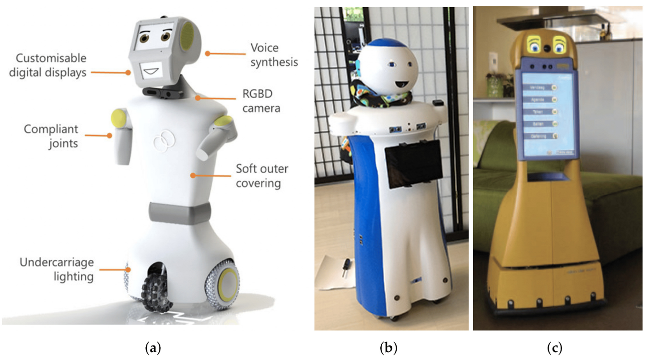

Fig. 1. Ikigai

of **database design**, the database is fundamental for securely and efficiently storing patient profiles and medication schedules while adhering to stringent data privacy regulations. Each **Patient Profile and Schedule** contains unique identifiers and detailed medication schedules, allowing the system to tailor reminders accurately for each patient. The **Interaction Logs** feature ensures that every interaction, including reminders and patient responses, is recorded with timestamps. This capability enables healthcare providers to track adherence over time and access patient records for evaluation. To maintain **Security and Privacy**, the system implements encryption and access controls to safeguard sensitive patient data, ensuring that only authorized individuals, such as healthcare providers, can access this information. The **Facial Recognition Module** is crucial for accurately identifying patients before each interaction. This module utilizes machine learning models trained to recognize specific facial features, enhancing the robot's ability to distinguish between different individuals. The process begins with **Image Capture and Preprocessing**, where the system captures an image of the patient's face. This image undergoes preprocessing, such as resizing and normalization, to improve model accuracy and ensure consistent recognition results. The **Recognition Model and Identity Verification** step involves using a model like FaceNet or a Convolutional Neural Network (CNN) for facial recognition. The model compares the captured image with the stored patient profile, confirming identity if the match meets a predetermined confidence threshold, thereby ensuring that the robot interacts only with recognized patients. The **Medication Reminder System** is

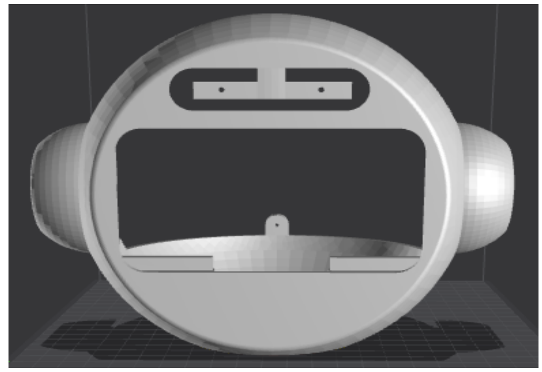

Fig. 2. 3D Design of Ikigai

integral to the robot's functionality, delivering reminders at specific times based on each patient's profile and logging responses to support better adherence. The system utilizes **Reminder Logic and Scheduling** to regularly check the database for upcoming medication times. When the scheduled time for medication arrives, the robot generates a reminder tailored to the patient's unique schedule. Through **Notification and Feedback**, the robot issues reminders using both audio and visual cues to ensure that the patient is aware of the prompt. Following the reminder, the robot poses the question, "Have you taken your medicine?" to confirm adherence. If the patient confirms they have taken the medication, the system logs this response as successful. In cases where the patient does not respond, the robot repeats the reminder as necessary, ensuring that no dose is missed. The **Conversational AI

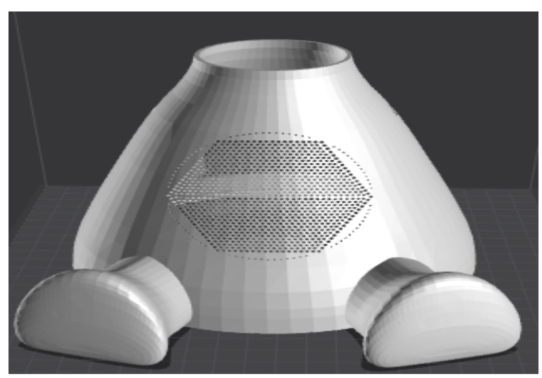

Fig. 3. 3D Design of Ikigai

Module** enables the robot to interact with patients using simple, structured dialogues. Through **NLP-Based Interaction**, the system processes patient responses, allowing the robot to recognize basic feedback such as "Yes" or "No." Additionally, the system is equipped to handle clarifying questions or follow-up reminders if the patient does not respond initially. This adaptive feature ensures that patient interactions remain fluid and supportive. The **Feedback Logging and Adaptation** process captures the patient's responses, allowing healthcare providers to monitor adherence closely. Moreover, feedback from patients aids the system in adjusting its responses over time, creating a more personalized interaction experience. For **Testing and Validation**, the system undergoes thorough usability testing to ensure its accuracy in identifying patients, delivering reminders, and interacting effectively. This includes **Usability Testing** in real-world scenarios involving patients to measure critical aspects such as recognition accuracy, reminder timing, and the quality of conversations. Tests are designed to evaluate how well the robot identifies patients, issues timely reminders, and engages patients in meaningful interactions. The **Success Metrics** for the system include facial recognition accuracy, improvements in adherence rates, and overall patient satisfaction, with patient feedback collected through surveys to assess comfort, satisfaction, and ease of use. The **Evaluation and Discussion** phase involves analyzing the results post-testing to evaluate the system's overall effectiveness and identify areas for improvement. **Limitations** may arise, such as difficulties in facial recognition under low-light conditions or variations in facial features, along with patients' comfort levels in interacting with the robot. **Proposed Enhancements** for the system include improving the NLP model for more complex dialogues, upgrading hardware components to enhance recognition accuracy, and integrating remote monitoring options for caregivers to oversee patient adherence more effectively. In **Conclusion**, the facial recognition and

Fig. 4. 3D Printed Ikigai

conversational AI-based robotic system presents significant promise in improving medication adherence through personalized reminders and interactive engagement. Future developments could further refine NLP capabilities, incorporate more advanced recognition algorithms, and enhance data-sharing features for healthcare providers. By adopting this combined approach, the system aims to contribute to better health outcomes, effectively addressing the common challenges associated with non-adherence in patient care.

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